Coastal Water Council - Stakeholder Board Meeting

Ringkøbing, April 21st, 2023

Modelling the Circulation in Ringkøbing Fjord

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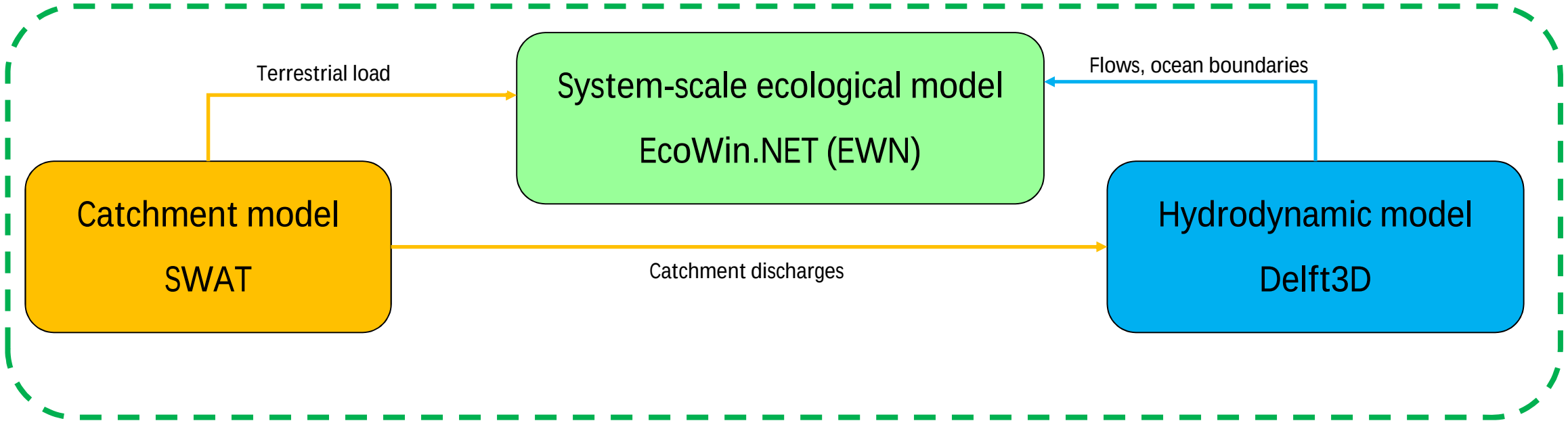
Circulation modelling in SUCCESS



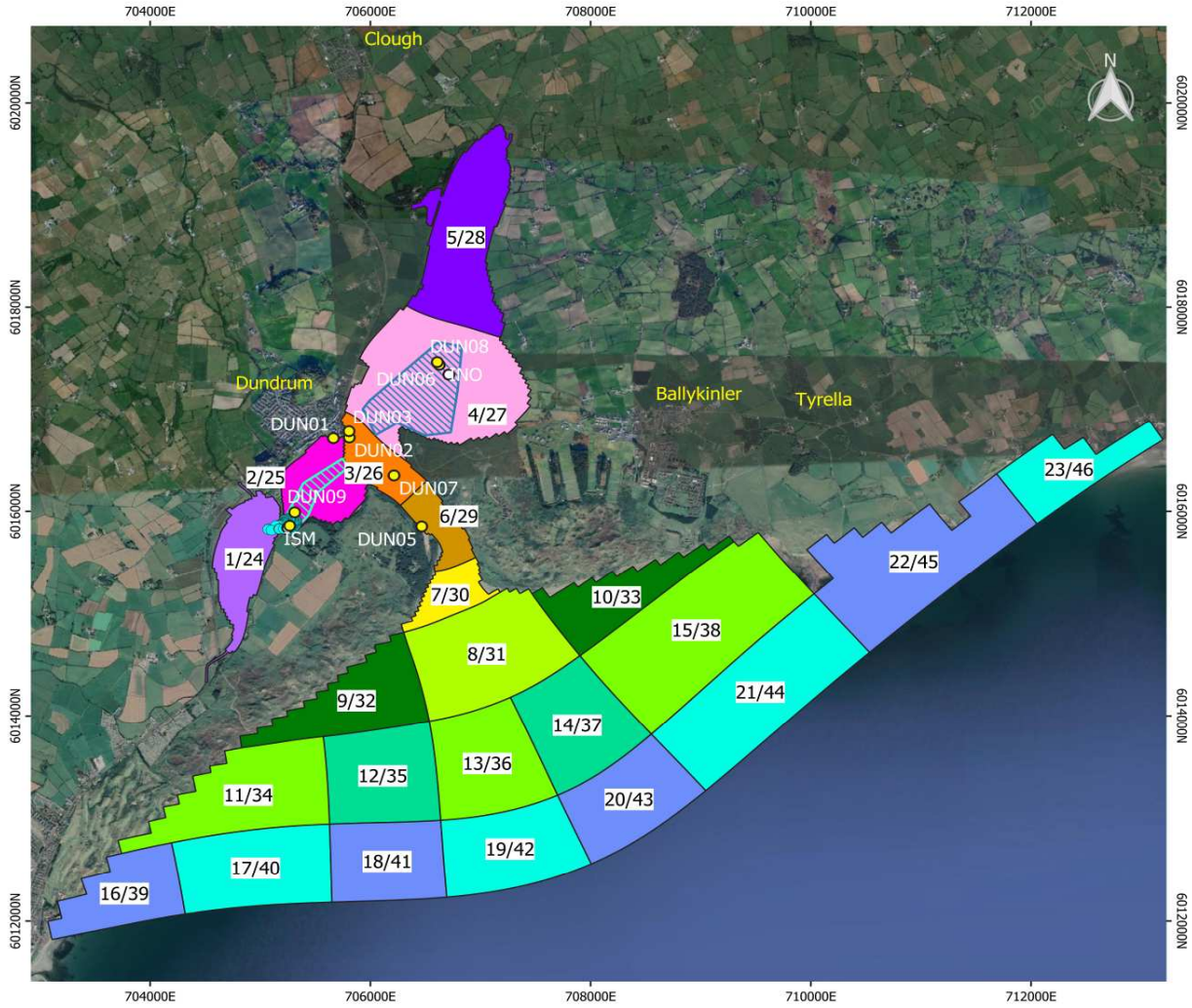
Products

- Stand-alone, high-resolution 3-dimensional hydrodynamic model
- Circulation results (flushing time, salinity, temperature, stratification)
- Simulated cenarios of exchange with the North Sea and freshwater input

Upscaling example: Dundrum Bay, N. Ireland, UK

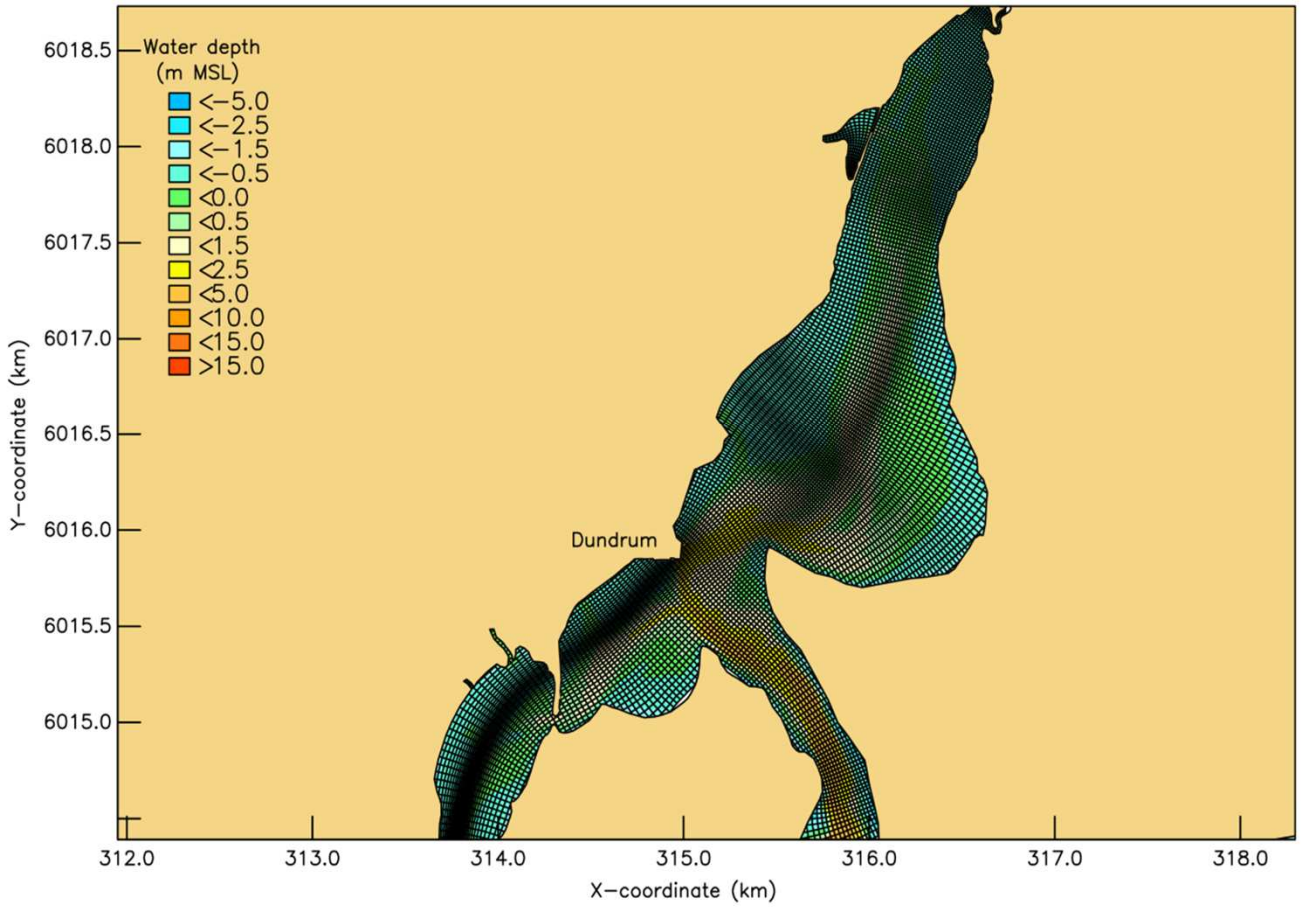
Boxes based on:

- Physical (depth, current velocity, ...)
- Ecological (Marsh, sandy, ...)
- Human activities (Cultivated, wild, ...)
- Administrative (WFD, regional boundaries,...)

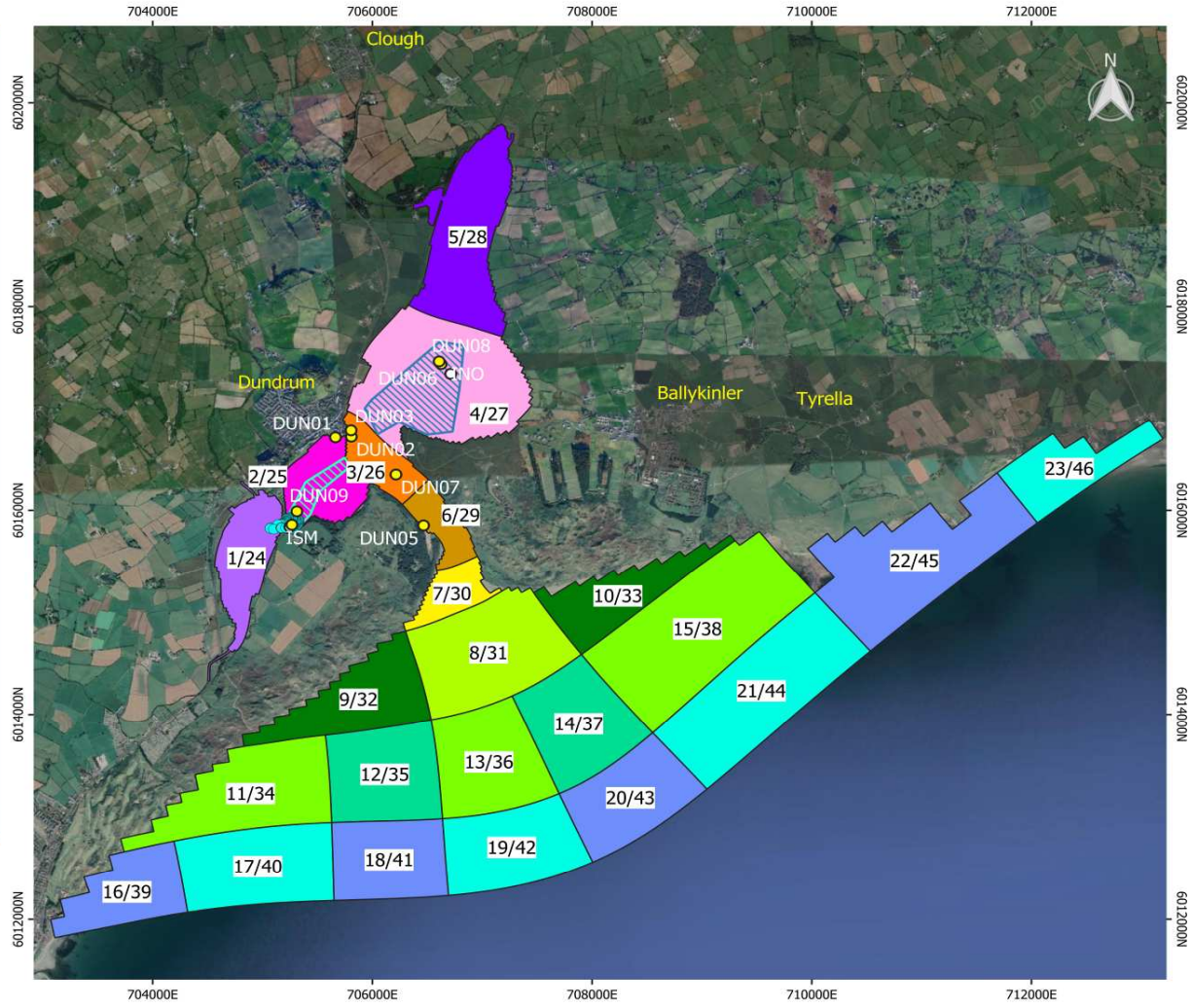


Upscaling example: Dundrum Bay, N. Ireland, UK

Circulation model



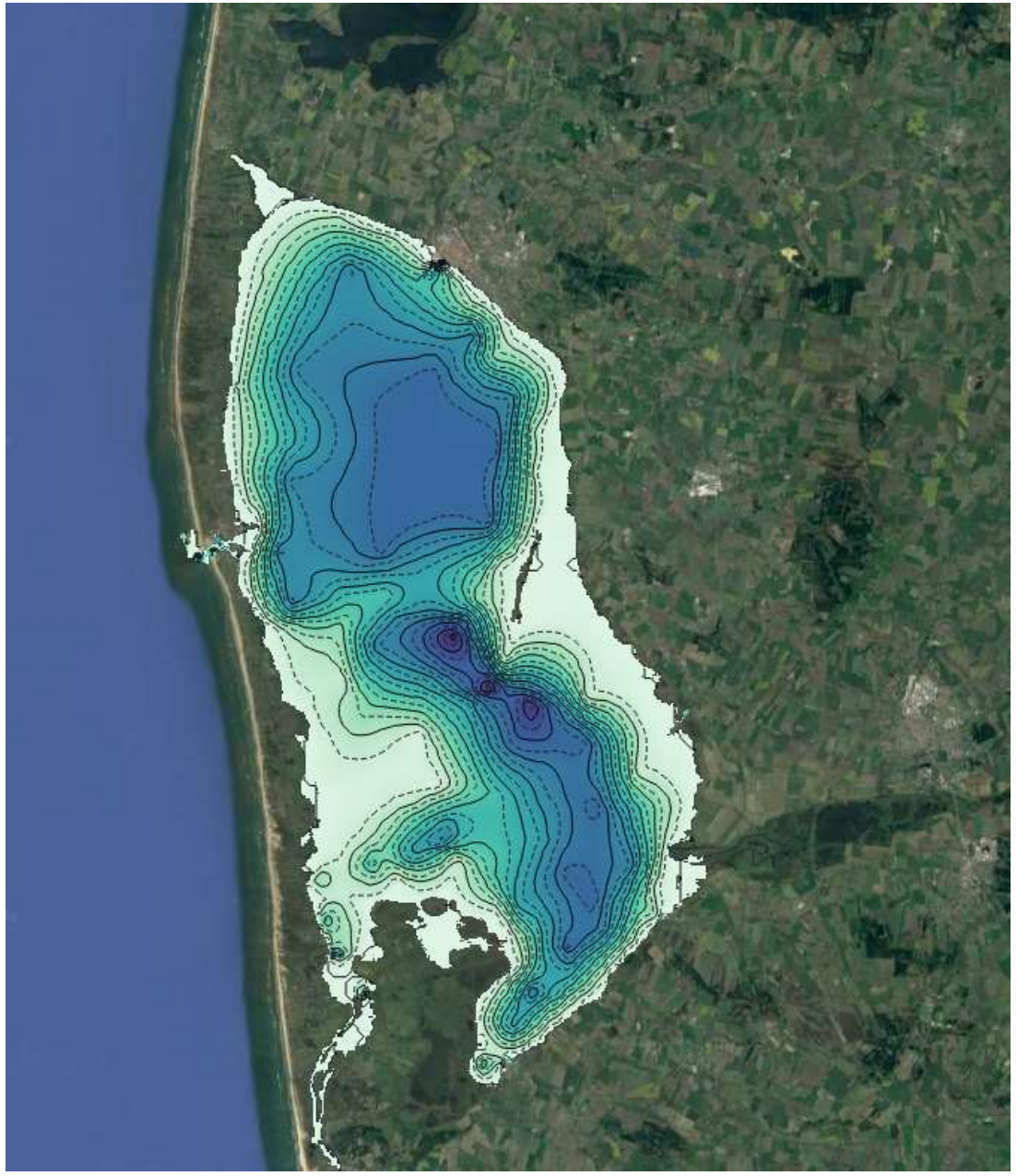
Ecosystem model



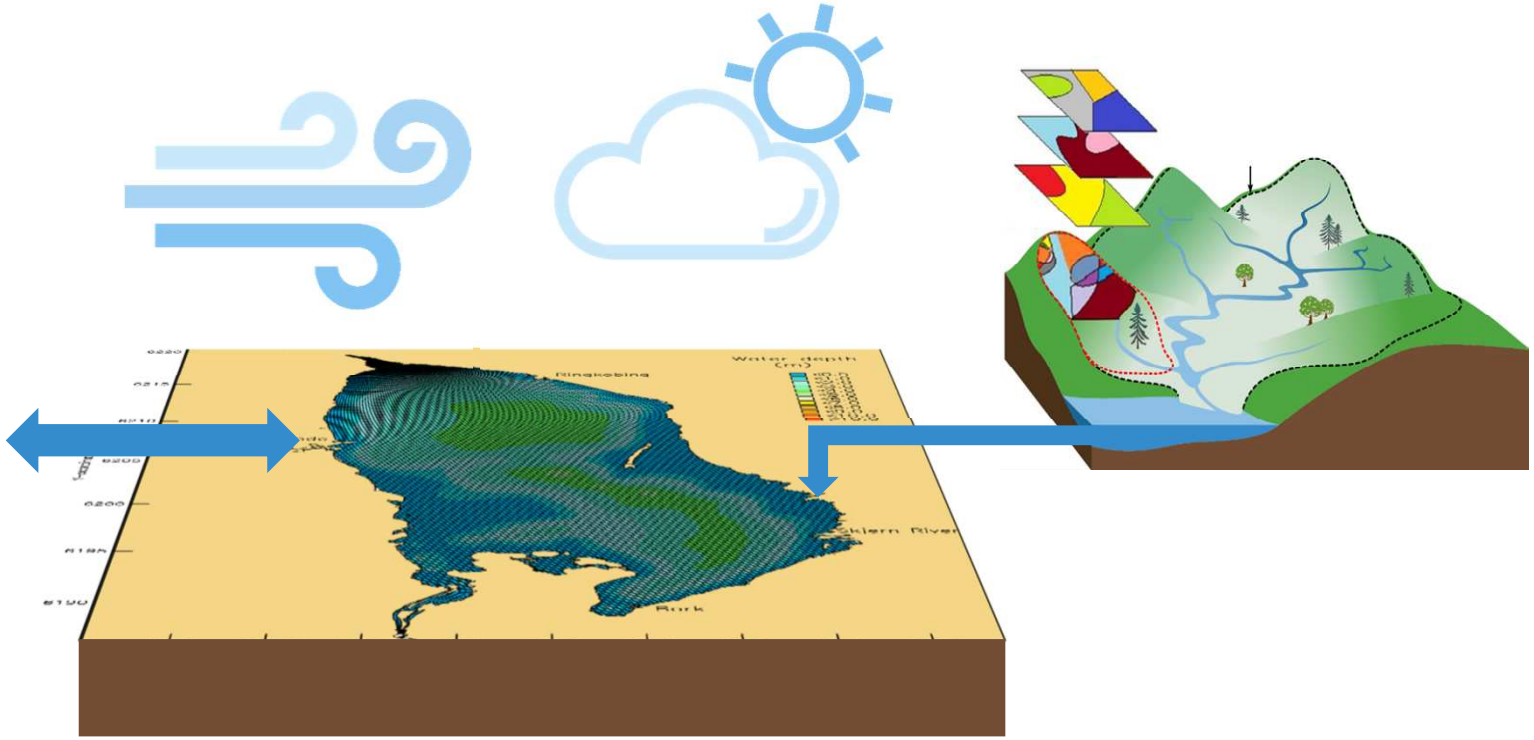
Circulation processes in Ringkøbing Fjord

The system:

- Shallow water lagoon with restricted exchange with the North Sea
- Several freshwater input streams
- Brackish water
- Circulation mainly due to wind action
- Stratification by salinity and temperature leading to oxygen depletion

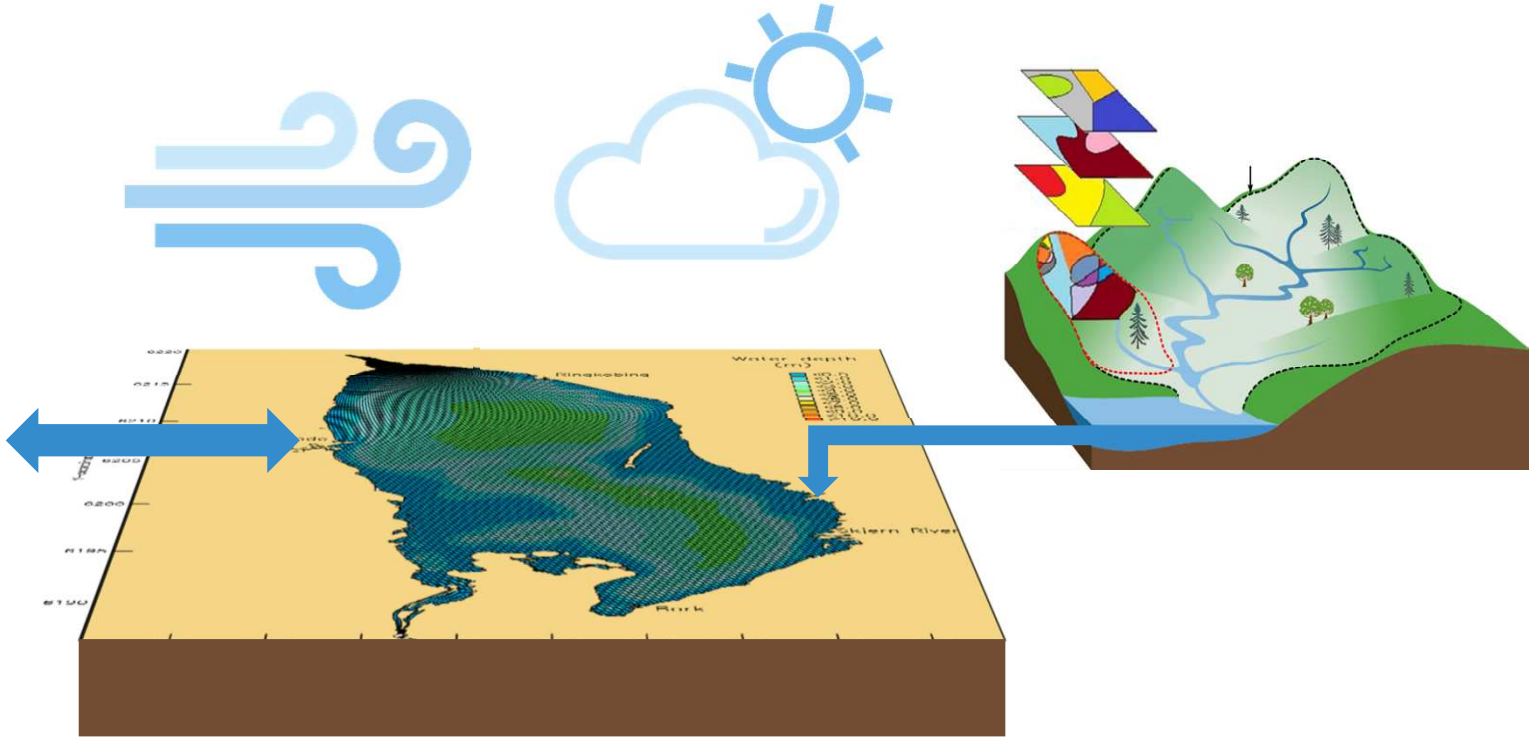


Modelling with Delft3d-Flow



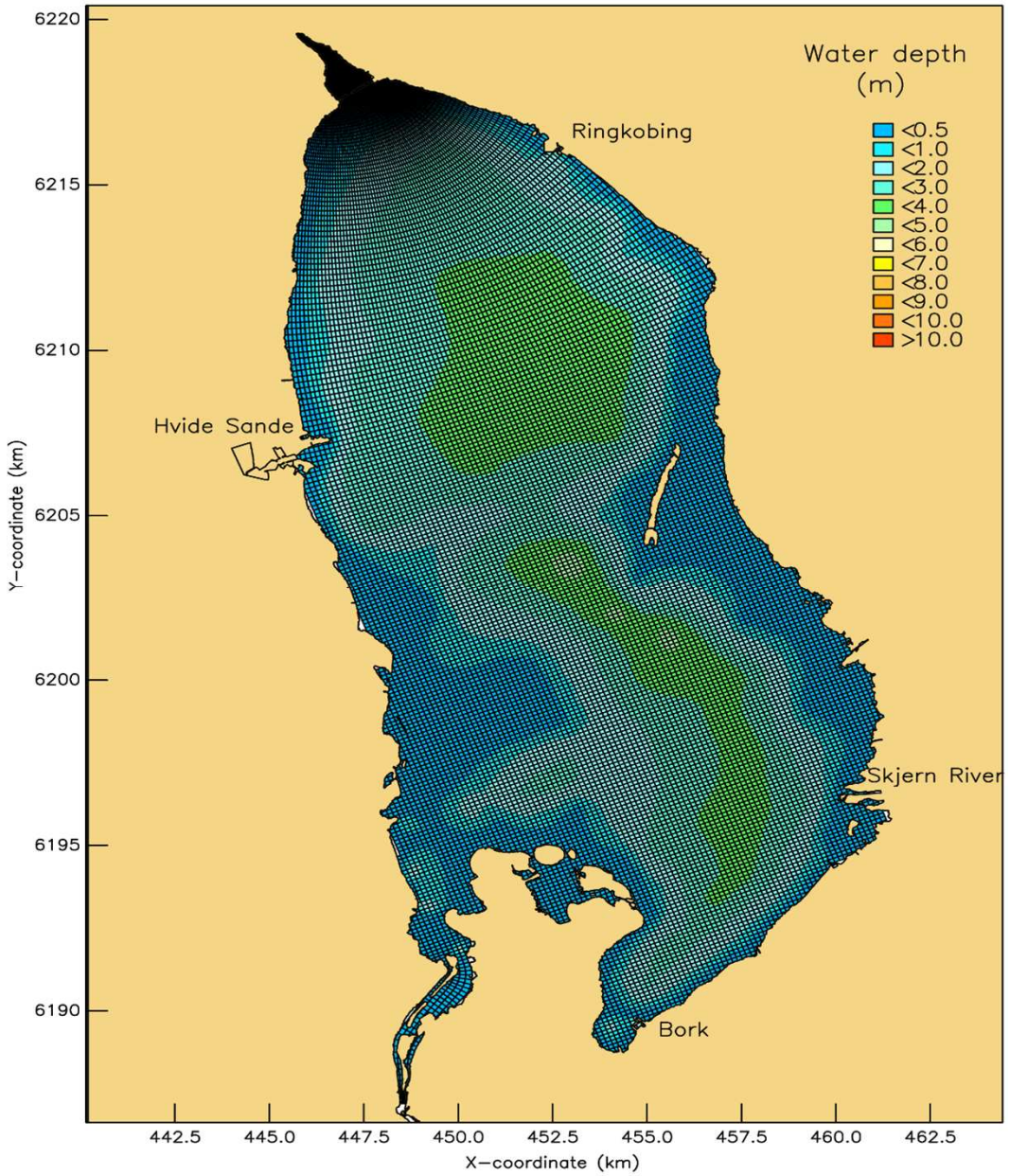
- Single domain curvilinear grid adapted to coastline and local bathymetry
- Exchange with the North Sea: results from Nielsen et al. (2005) and subsequent work
- Freshwater input from SWAT results
- Wind input from nearby meteo station or DMI model
- Water temperature with robust heat model using DMI model results for atmospheric forcing
- Calibration against measured data at several stations in the fjord

Modelling with Delft3d-Flow

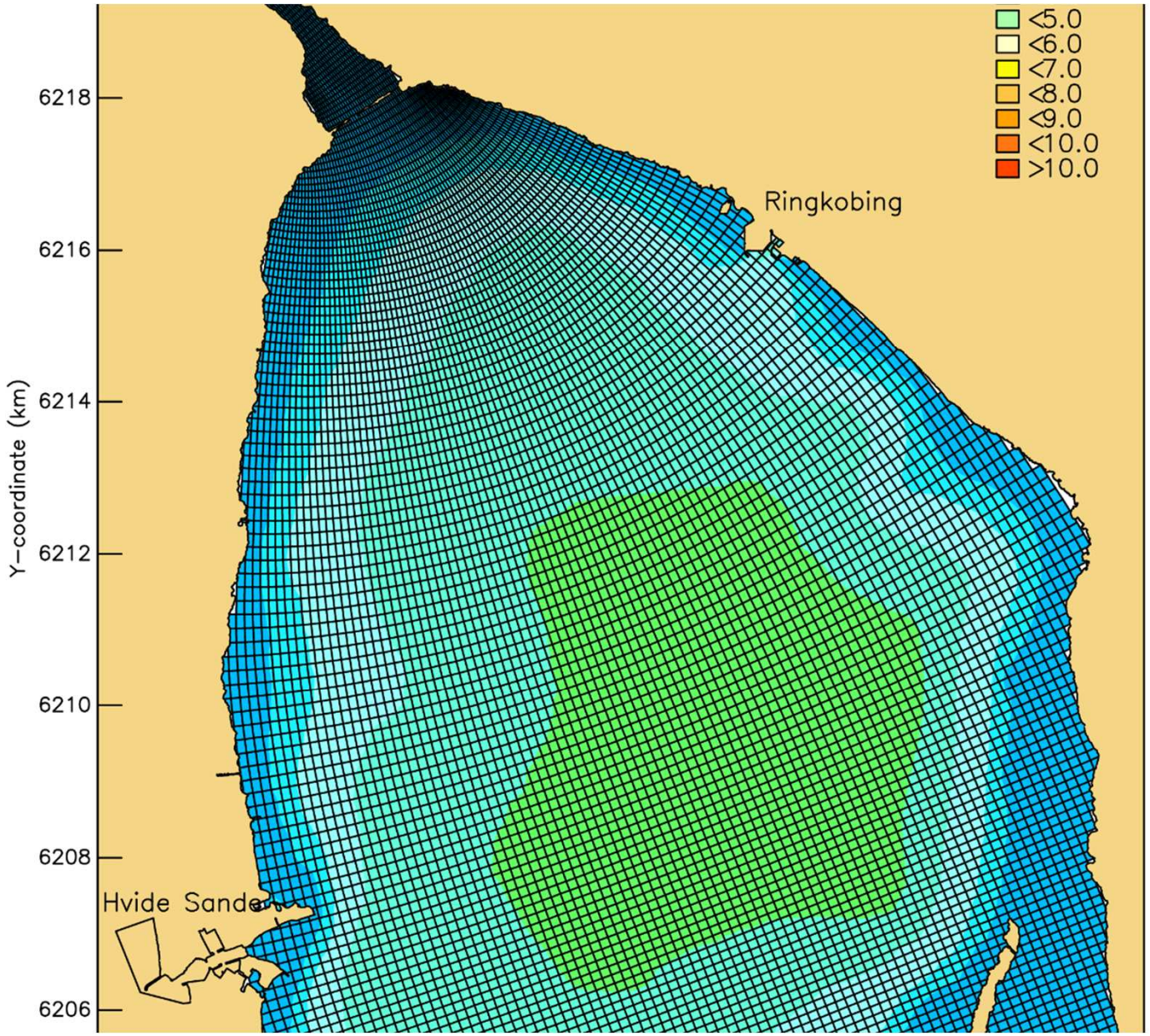


Status	Data requirements	Rationale
In progress	DMI Atmospheric data	Design
In progress	Bathymetry	Design
No data yet	Results from Sluice Exchange Model	Design
In progress	Freshwater inflow	Design
No data yet	Water levels	Calibration/Validation
No data yet	Salinity and temperature	Calibration/Validation

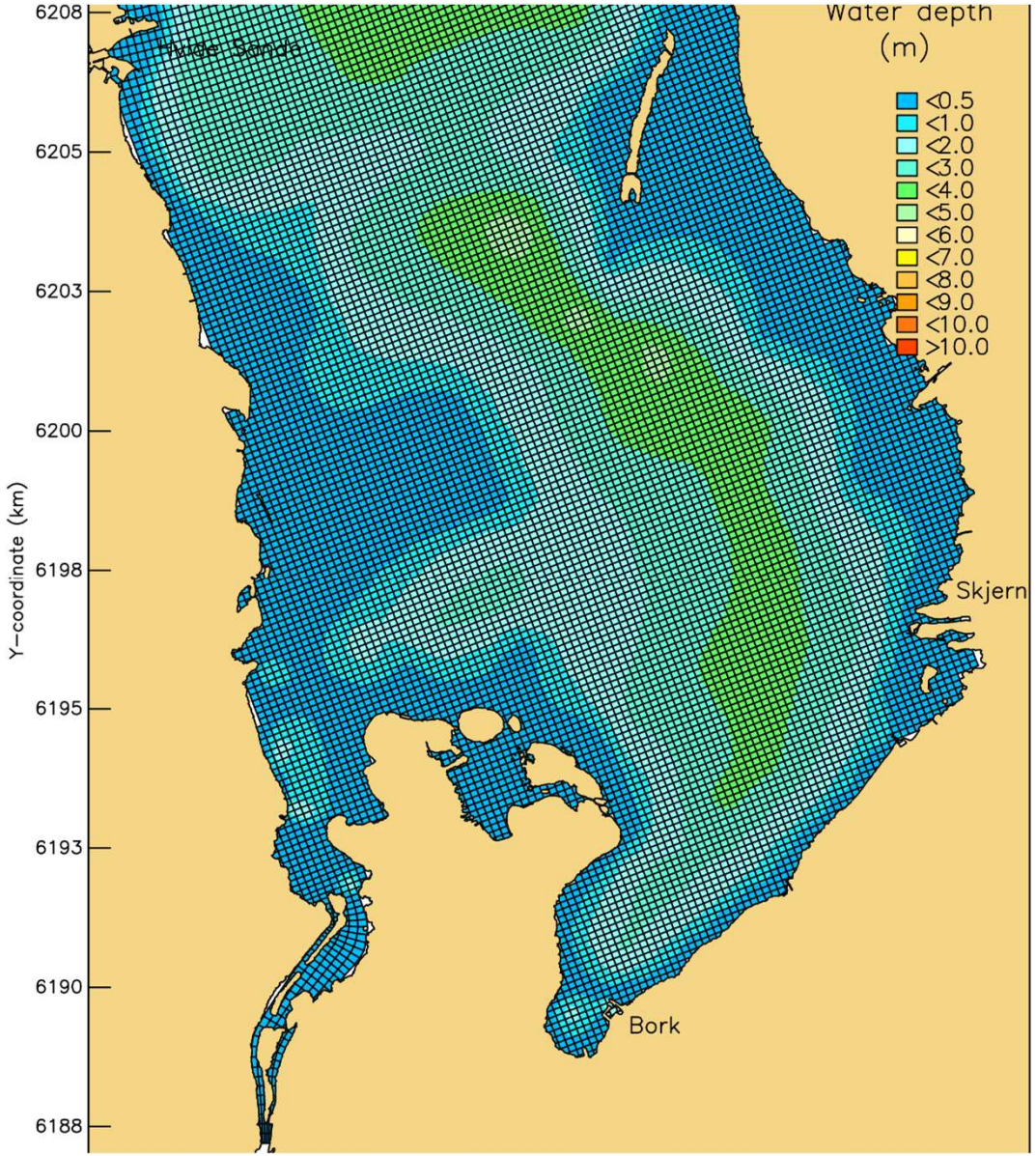
Work in progress: Grid design



Work in progress: Grid design



Work in progress: Grid design



Roadmap

In progress	Data compilation
	Domain design
To be completed	Water level calibration
	Salinity and temperature calibration
	Scenario production
	Upscaling to EWN

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SEGES INNOVATION

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Sand mussel (*Mya arenaria*) growth model

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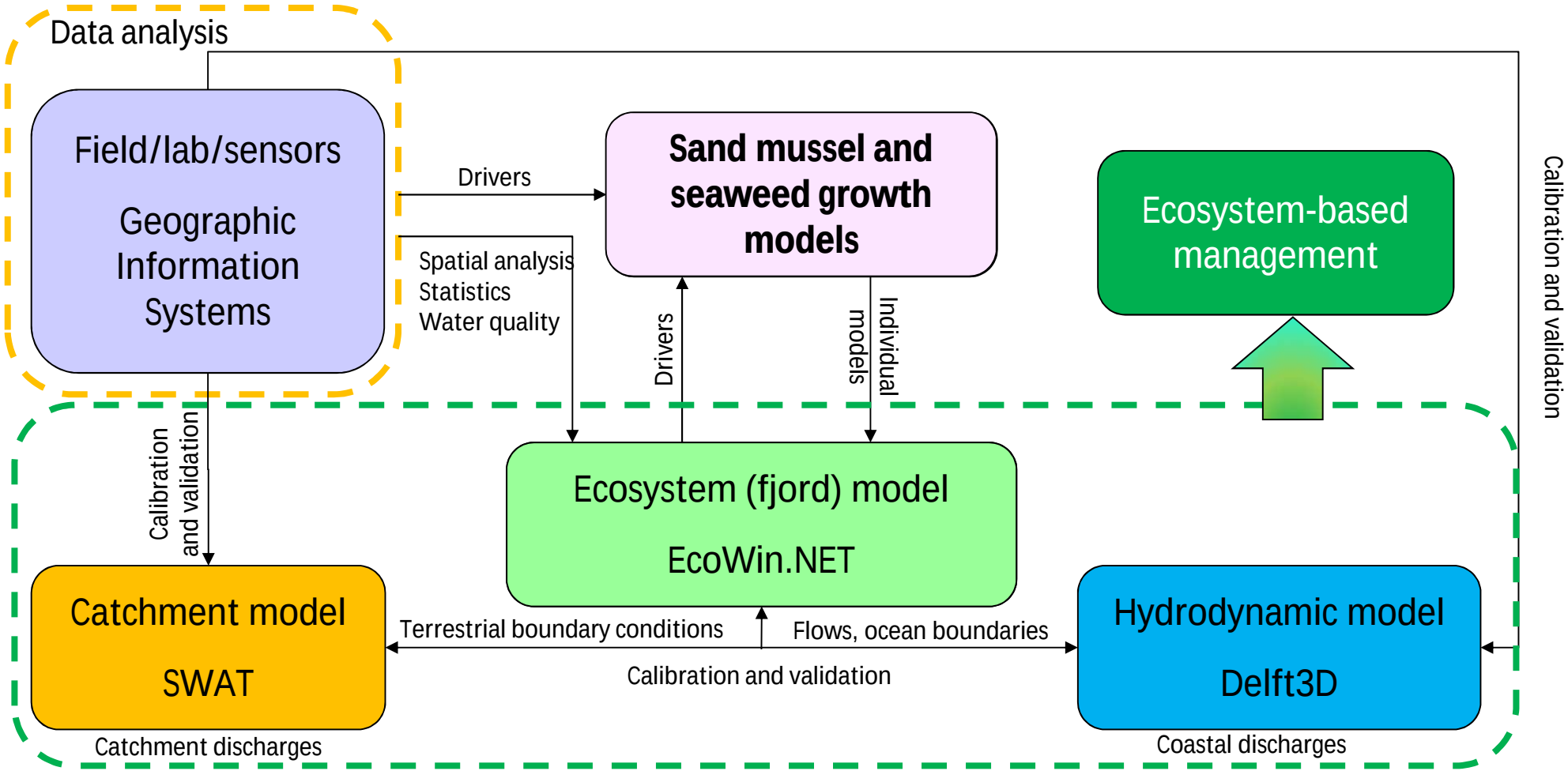
Modelling framework applied to Ringkobing Fjord for integrated management



Growth model for sand mussel (*Mya arenaria*) provides information to the ecosystem model on biomass production and environmental effects of the sand mussel population in the fjord.

Why do we need the sand mussel model?

- Sand mussels filter the water in the fjord of algae, improving water clarity;
- Help control phytoplankton biomass (algal blooms) and short-circuit eutrophication process;
- Improve the ecological status of the fjord, important to achieve WFD water quality standards (at least good ecological potential);

Ecological interactions of sand mussels in RK fjord

Low salinities are detrimental for sand mussel growth & survival

North Sea exchange

Salinity conditions

Microalgae (Chl-a)

Sand mussels (*Mya arenaria*)

Water clarity (Secchi depth)

Catchment inputs

Dissolved nutrients (N, P)

Seaweeds (*Ulva lactuca*)

Fine plant detritus

Seagrass (eelgrass)

WFD indicator of good ecological potential

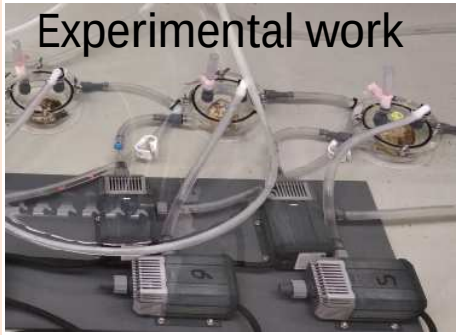
In 2019 low salinities triggered sand mussel mortalities and disappearance of seagrasses, worsening the ecological potential of the fjord.

Sand mussel growth model: workflow

DATA COMPILATION

Scientific literature

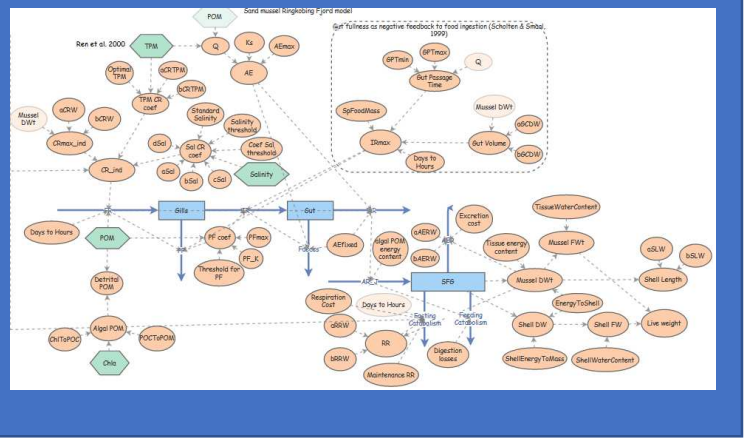
Experimental work



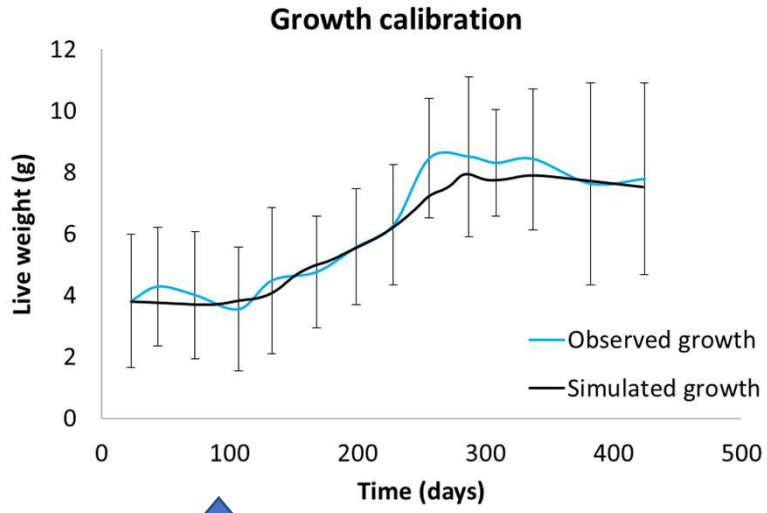
Field observations

MODEL DEVELOPMENT

Shellfish growth model

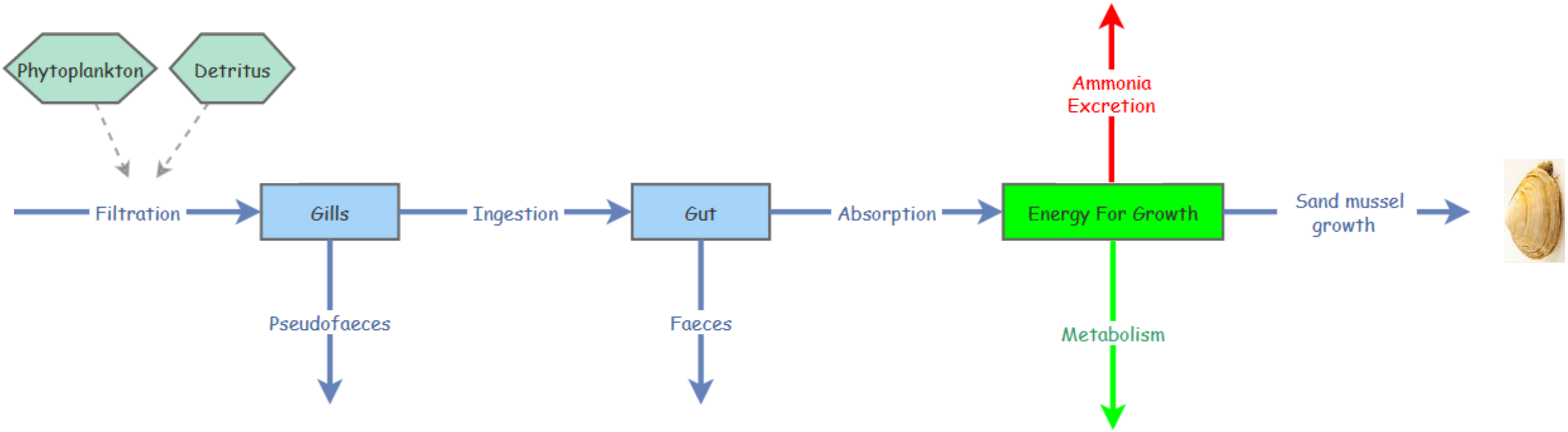


MODEL VERIFICATION



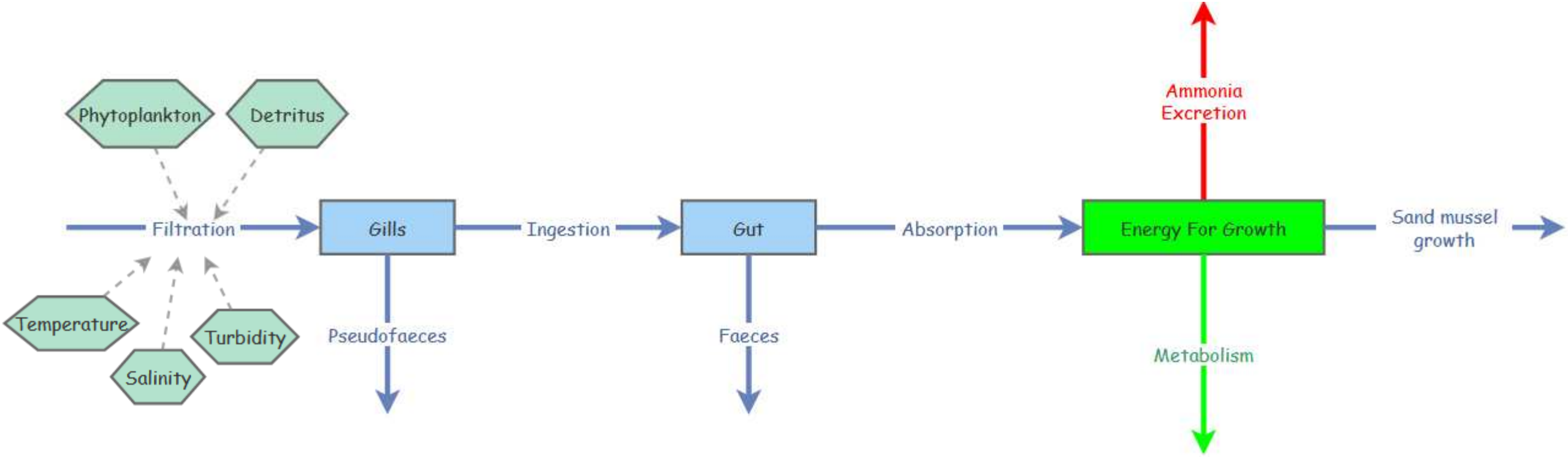
Model simulates physiology, growth, environmental footprint and mass balance of sand mussels.

How does the model simulate growth? We need to simulate its physiology first...



Growth is estimated as the energy inputs (feeding) minus the energy outputs (metabolic expenses).

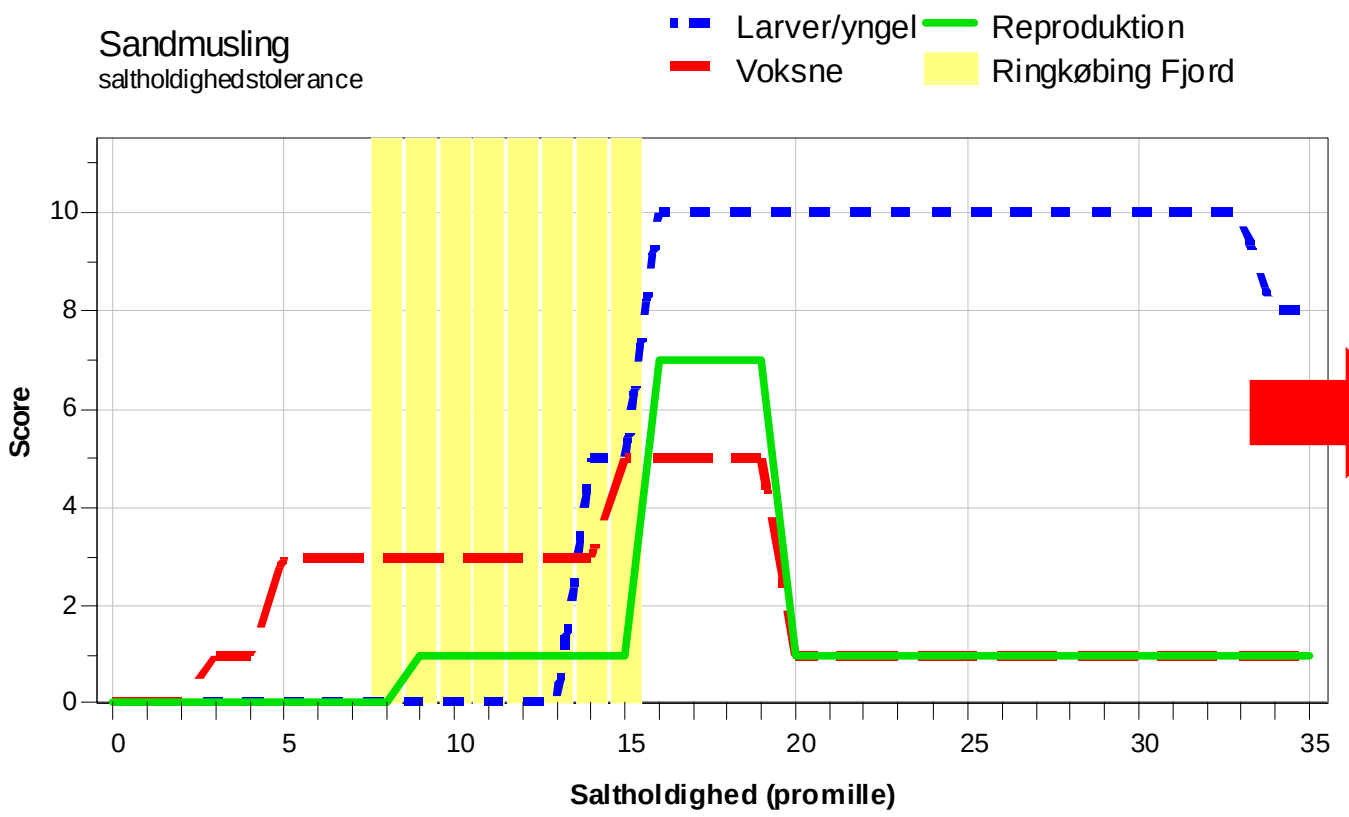
Which factors affect the physiological processes?



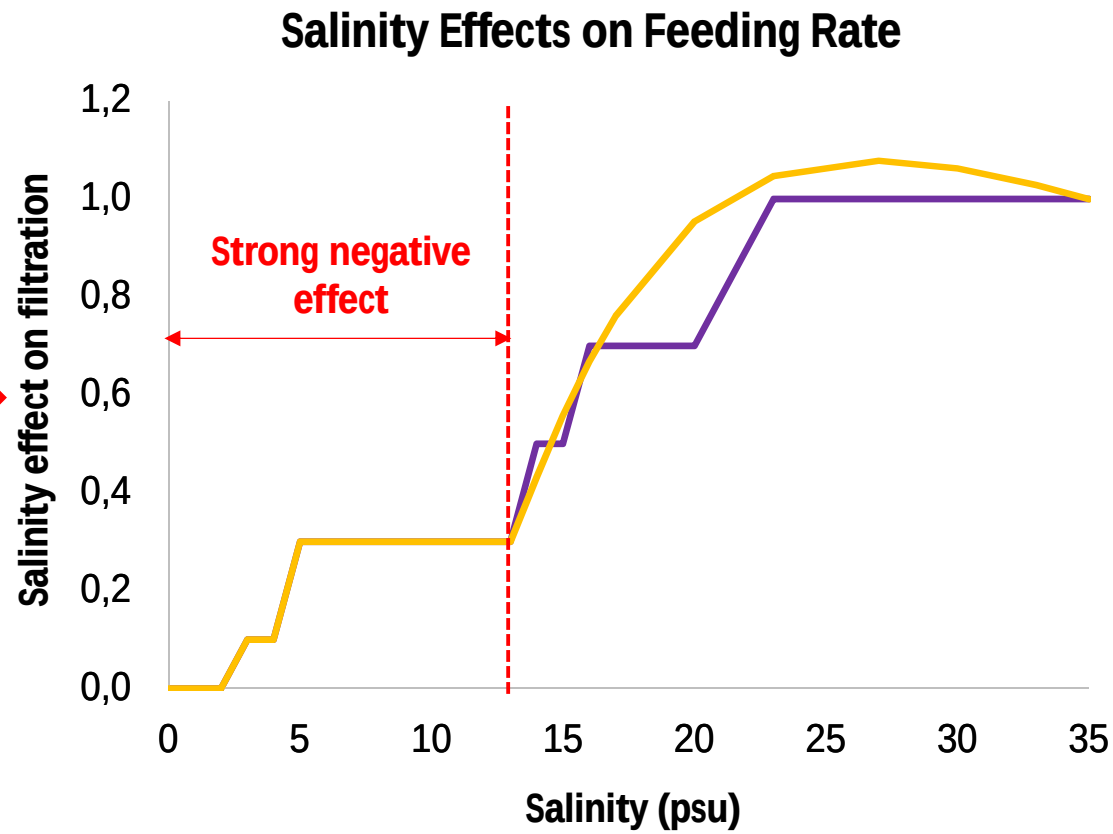
There are many factors affecting the feeding and metabolic rates, such as the size of the animal, food availability (phytoplankton and detritus), water temperature and salinity.

Salinity effects on sand mussel growth

FIELD DATA



SAND MUSSEL MODEL



The model accounts for the detrimental effect of low salinity on feeding rate. What measures can be taken to avoid salinity falling below the tolerance salinity range for sand mussels?

Data requirements for the growth model

Status	Data	Rationale
Completed	Water temperature and salinity	Model drivers
	Phytoplankton and detritus concentration	
	Concentration of suspended particles	
In progress	Temperature tolerance range	Model development
	Salinity tolerance range	
	Effect of salinity on filtration rate and mortality rate	
	Sand mussel abundance and coverage	
	Recruitment and mortality rates	
In progress	Average filtration rates	Verify model performance
	Mya arenaria growth rates in RK Fjord	

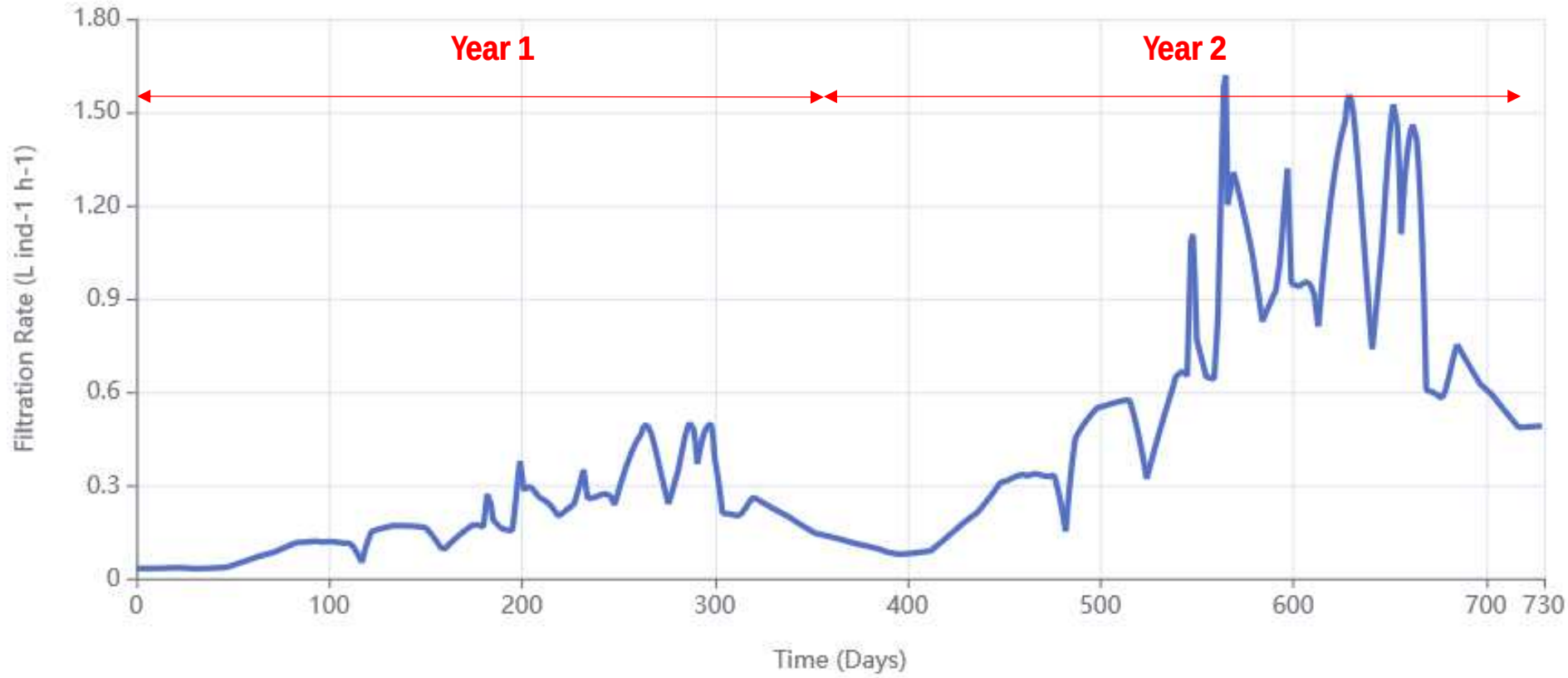
Models are driven by data. The better the data available, the more reliable the model results will be.

Can you help us getting the data for the model?

- What size do the sand mussels get?
- How long do they take to grow?
- When and where can we find sand mussels?
- Which are the numbers of sand mussels in the Fjord?

The model is driven by data. The better the data available, the more reliable the model will be.

Preliminary model outputs: Filtration



Sand mussels were able to clear up to 1.6 L of water per hour from particles, that is up to 38.4 L per day. Considering a density of 60 ind. m^{-2}, sand mussels would be able to filter the whole fjord each day.

Main outcomes of the sand mussel model

- Water clearing potential of the sand mussel population in the Fjord;
- Net nutrient (N & P) removal;
- Biodeposition of organic matter to the sediments;
- Biomass production of sand mussels;
- Assess top-down control of eutrophication symptoms.

Test scenarios with different densities of sand mussels to see effect on phytoplankton biomass, water clarity, and compliance with WFD quality standards.

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Tak for Deres opmærksomhed

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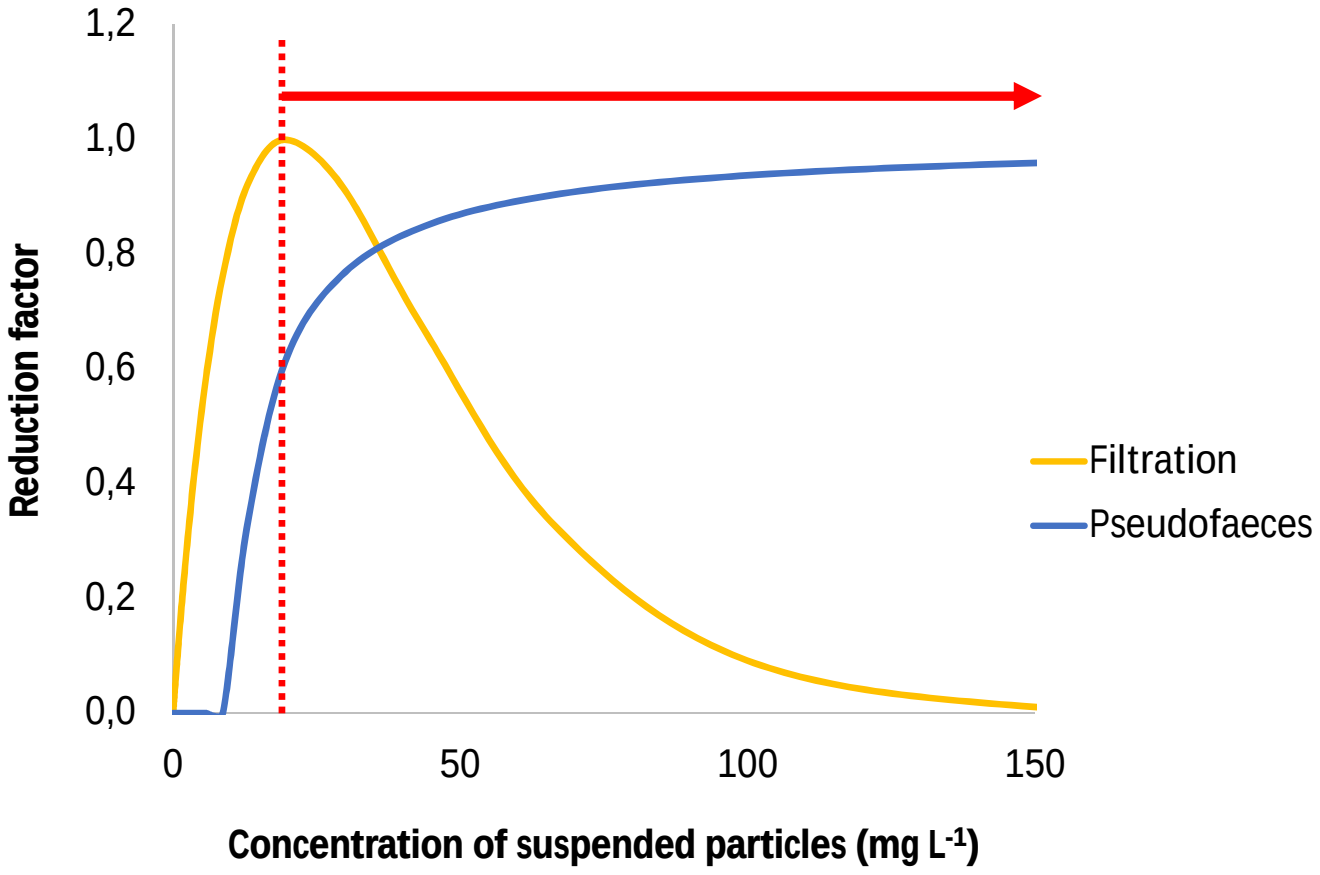
Model outputs: sand mussel growth curves

The model estimates a growth rate of 2.7 cm shell length per year and 1 g live weight per month.

Effect of turbidity (suspended particles) on filtration rate



High turbidity has a detrimental effect on filtration capacity and growth of sand mussels.

Expected model outputs: Mass balance